SUSTAINABILITY IN PRESERVATION ENGINEERING EDUCATION: CULTIVATING A CONSCIOUS & CONSCIENTIOUS PRACTICE

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Sustainability in the conservation and preservation of cultural heritage is not a topic that can be neatly defined within conventional engineering technical disciplines, nor can it be achieved by the application of prescriptive or formulaic solutions. Nonetheless, it is essential to preservation engineering practice in the present and the future, and must be addressed as part of a curriculum in preservation engineering.

This position paper explores:

- Sustainability and cultural heritage;
- Sustainability in cultural heritage;
- Sustainability in preservation engineering practice;
- Sustainability in the preservation engineering curriculum;
- Research opportunities for sustainability in preservation engineering.

Sustainability and Cultural Heritage

Before we consider the pedagogy for sustainability and preservation engineering, let us consider what sustainability means, and how it applies in the contexts of cultural heritage and the Preservation Engineer's practice.

Wikipedia tells us: "Sustainability, in general terms, is the ability to maintain balance of a certain process or state in any system" noting that human sustainability is typically taken to integrate social, economic and environmental spheres.[1] In 1989, the *World Commission on Environment and Development* (Brundtland Commission) articulated what has been a widely accepted definition of sustainability: "[to meet] the needs of the present without compromising the ability of future generations to meet their own needs."

Embedded, explicitly and implicitly, in these and other definitions of sustainability are:

- Intergenerational responsibility;
- Integration of social, economic and environmental spheres;
- Capacity and need;
- Thinking in long-time;
- Finding a balance;
- Follow-through.

Intergenerational responsibility is the foundation for stewardship of cultural heritage. However, in cultural heritage we might think of our responsibility in the limited sense of preserving the integrity of moveable or immoveable heritage for future generations.

Sustainability pushes that boundary of intergenerational responsibility beyond the *thing*, requiring that we include the social, environmental and economic impacts of our efforts, and leaving us to find the balance point of a complex, dynamic interrelationship of cultural heritage and the three spheres within which it must reside.

A sustainable approach starts with an understanding of need, in the true sense of necessity. Reciprocal to necessity, but not explicitly stated, is an understanding of capacity. A sustainable approach requires that needs be met within our social, economic and environmental capacities.

So sustainability in cultural heritage requires that we have an understanding of the multi-variant needs and capacities of a stewardship institution and the heritage for which it is responsible. Examples of these include: financial resources, human resources, technological sophistication of the institution, visitor market, building envelope performance, building size, site size, community support, and utility and transportation infrastructure.

Central to the concept of sustainability is a long view of time, implied by the intergenerational compact. Long-time has also been fundamental to cultural heritage, for heritage is the aggregate result of changes over past long-time. But stewardship of cultural heritage must also be forward-looking in long-time if we are to limit those changes that result in value-robbing deterioration or loss.

There are two links between change and time. The first is the inevitability of change over time due to entropy and the second law of thermodynamics, something well known to engineers and the intrinsic challenge in conservation and preservation of materials. Sometimes change in cultural heritage, such as patina, adds value, but more often change, such as corrosive loss, reduces value. The second link between change and time is that change provides the basis for our own psychological sense of time. We mark time by observing and experiencing change; when we recount our life experiences, we typically benchmark time to significant changes or events.

Thinking in long-time is challenging because we function in the present, against the background of our total experience of time. Our sense of time in the present is compressed by technology; the present is defined by increasingly shorter intervals of time. Anyone who uses email or instant messages can attest to the immediacy and brevity of the present. However, the present offers us a very small window within which to observe, identify and measure the large scale driving forces and resultant changes that affect cultural heritage, and the environment, in long-time.

Thinking in long-time is necessary for sustainability because it puts service life expectancy of interventions into the larger time frame of cultural heritage. This enables us to consider how our interventions of new parts, materials or systems can be maintained or replaced with minimal harm or disturbance to the original heritage fabric we are trying to preserve for future generations.

If we broaden our view of long-time to include the social, economic and environmental spheres that are the basis for sustainability, we can begin to identify trends and patterns in large scale driving forces that can affect cultural heritage, such as national and global economies, energy resource availability and costs, technology, climate change and social and governmental stability.

Some of these long-time driving forces seem so slow that they might be perceived as static especially in present time, but they are in fact highly dynamic and synergistic, sometimes culminating in rapid and significant change.

Over the decade or two, several events have occurred that have had lasting direct and indirect implications for cultural heritage. The flooding of New Orleans after Hurricane Katrina, the global credit market collapse, the international scientific acknowledgement of human-influenced climate change and the increasing global demand for energy are examples. But in retrospective study, we realize that these events have been the result of long slow trends that were generally just outside our temporal range of thinking, but not outside the range of available information.

Taking the long-view and a broad perspective of sustainability will not prevent these large driving forces. However, it helps us as preservation engineer to consider "what if" scenarios, and to include these scenarios in our design thinking. These themes of long time, durability and design are explored in Steward Brand's *The Clock of the Long Now*.[2] They can also be reviewed at the website of The Long Now Foundation.[3]

Sustainability also includes the directive to find "balance" of multiple variables across social, economic and environmental spheres. To an engineer, striking balance sounds a lot like the pejorative "compromise," and might even be antithetical to the engineer's notions of quantitative precision and certainty.

Lastly, sustainability is not attained in a single moment of accomplishment; sustainability can only be accomplished it is maintained by an on-going process of measurement, feedback and adjustment to confirm that objectives are met. In long-time, the driving forces that affect cultural heritage will vary, so in order to maintain sustainability, we determine the applicable metrics, monitor results and adjust our strategic responses as needed.

Sustainability in Cultural Heritage: An Example

As an example of sustainable cultural heritage, let us consider a specific engineering problem - interior environmental management for collections conservation.

For the past few decades, the goal of objects conservation has been to minimize change in objects by providing an "ideal" conservation environment for collections and the logic followed that if tight control is good for objects, tighter control must be even better.

Being expert problem solvers, we engineers responded by designing sophisticated mechanical systems for heating, cooling, filtration and relative humidity control, precisely what "the customer ordered."

In assessing the tightening of relative humidity specifications for museums, J. P. Brown and William Rose noted in 1997 that:

> As mechanical systems increased in sophistication, there arose a general feeling that if ±5%RH was good, then ±3, or even ±2%RH, must inevitably be better... Any deviation from mid-point humidity became a cause for alarm and again, because little quantitative research on the effects of different levels of humidity variation had been carried out, it was felt sensible to play safe by keeping as exactly to the rules as possible… Also, it was assumed that if close control (±2%RH) provided no more benefit for the objects than wider control (±5%RH), then at least it did no harm; therefore, why not have the tightest level of control that was possible? In fact, we believe that the inward spiral of humidity tolerances proceeded from a fundamental miscommunication between museum staff (conservators, curators) on the one hand, and mechanical engineers on the other."

There have been four consequences to this approach. First, the cost of control follows the curve of diminishing returns, and the tightest control becomes prohibitively expensive in energy and currency. Second, the equipment has a finite service life, usually 20 to 30 year cycle and the most sophisticated part of the system, the controls, may be technologically obsolete within 5 years of installation. Since these mechanical systems are usually hidden in the nether spaces of the building, heroic efforts are required for replacement. Last, energy consumption by buildings is a major component in our generation of greenhouse gases that affect global climate. So we were making the exterior climate worse by trying to over-control the interior environment.

The realization of the implications of tight control has led to an emergent view in the collections conservation field that the prescriptive approach of tight mechanical control for collections environments is not sustainable for the cultural heritage sector. Simpler, more robust systems, with a wider band of acceptable temperature and relative humidity, often incorporating passive qualities of the building itself for thermal inertia, moisture buffering and natural ventilation are needed.[4]

It is instructive to consider how this emerging viewpoint on sustainability for moveable property is applied in practice, in order to identify what characteristics are applicable to broader issues in preservation engineering:

- Interdisciplinary collaboration: The process engages technical and non-technical professionals and stakeholders throughout the project phases. This requires skilled facilitation and communication, especially active *listening* to others who may use a different professional jargon;

- Understanding the historical, environmental, cultural and technological history of the cultural resource. This necessarily involves gathering and analyzing data and information on historic contexts, past design and technology and past performance. This also requires that the Preservation Engineer have a deep appreciation for what has been done before;

- Determination of needs. The formulation of a critical part of the problem statement. What is necessary and why; if we don't comprehend the *why* part, we are merely designing by prescription or recipe;

- Assessment of capacity. Capacity is defined not only in the engineering sense of available space or thermal or structural loads, but equally important, in the sense of an organization's technological and financial capacity to implement and maintain what is designed. Financial capacity is assessed with respect to the cost of operation, and also with respect to the cost of replacement based on the service life cycle;

- Scenario planning. History tells us about what has happened in the past. What can happen in the future? What long-cycle driving forces might have to be addressed that are different from today's design context? Design solutions should be robust, adaptable and flexible enough to address these potential changes in long-time;

- Finding the balance point. The multi-variant objectives must be balanced by the team. Some objectives may be conflicting, competing or even mutually exclusive. Occasionally, imperfect solutions or "close enough" must be accepted. As engineers, we are trained to calculate the "right" answer, but we must also has to be able to work with less certain, somewhat ambiguous results;

- Follow-through to maintain sustainability. Sustainability is not determined by points or a score; the context in which we strive to be sustainable is dynamic and changing. So sustainability must be maintained by an active process of monitoring against known metrics, feedback and adjustment as the context changes. This implies that there is some basis for measurement.

Although these characteristics have been related to the challenge of sustainability and environmental management for moveable property, they are applicable to sustainability and cultural heritage in the larger sense of buildings and sites.

Sustainability as a Practice

In practice, a Preservation Engineer may apply knowledge of strength of materials one day, and knowledge of life safety codes the next and perhaps experience in building deterioration the next.

However, sustainability, like preservation or conservation, is not reducible to a formula or recipe. Instead, sustainability involves a way of thinking about, and analyzing, issues in cultural heritage that treats each situation as unique, and encompasses a wide range of non-technical and perhaps qualitative considerations.

We might think of sustainability as a *conscientious and conscious practice* for the Preservation Engineer:

- *Conscientious* in the sense that we embrace our responsibilities with respect to the impact of our actions in the broad context of the social, environmental and economic spheres;
- *Conscious* in the sense of awareness and introspection with regard to our thought processes, communications, decisions and actions;
- *Practice* in the sense that we habitually and continually refine and improve on what we are doing as professionals.

In this regard, sustainability for the Preservation Engineer is more akin to professional ethics than to more technical topics, such as strength of materials or moisture vapor transport in building assemblies.

Sustainability to the Preservation Engineering Curriculum

If we are correct in identifying what sustainability in cultural heritage is, and how it is applied in practice by the Preservation Engineer, then we can come back to the question of how to teach it to future Preservation Engineers.

The first part of the answer is a statement of the learning objectives. It seems that we would want a Preservation Engineer to be able to:

- Articulate a clear set of values with respect to both cultural heritage and sustainability;
- Respect the work of engineers, architects and builders before us, for what they were able to accomplish;
- Practice critical thinking;
- Think about the past and future in the framework of long-time;
- Identify and define a problem that is embedded within a set of apparently "messy" and possibly unrelated constraints, rather than being expressed as a clear problem statement;
- Creatively solve multi-variant problems that have qualitative as well as quantitative aspects;
- Objectively evaluate multiple solutions and options using various methods;
- Effectively communicate with, including listening to, non-engineers on technical and non-technical matters;
- Productively collaborate with other professionals, technical and non-technical, in interdisciplinary problem identification and solution.

The second part of the answer is how we can meet these learning objectives through an effective learning experience. This is probably not a single course titled "Sustainable Preservation Engineering" but rather a program-wide ethos that treats sustainability at the same level of importance as cultural heritage itself.

This ethos would be *put into practice* in the classroom, not as lectures, but as a continuum of learning opportunities in which real world problems in cultural heritage and sustainability are tackled through collaborative, interdisciplinary group work and engagement in solving case studies. These case studies, like Preservation Engineering itself, would transcend conventional engineering disciplines, demonstrating the variety and ambiguity of the situations that are encountered in practice.

The case study as an active group task has proven to be an effective learning methodology in cultural heritage, especially as a tool for integrating multiple disciplines on a problem as well as teaching collaboration. This approach has been employed in the NCPTT's professional development courses *Engineering for Older Buildings*.[5] At the Centre for Sustainable Heritage, University College London, an information-rich and highly sophisticated on-going case study of a heritage building forms the learning methodology for Module 3, Sustainable Strategies, in the Master of Science program in Sustainable Heritage.[6] For those case studies that involve design, experience in Creative Problem Solving might also be included.[7]

Research Opportunities

Sustainability in cultural heritage offers a wide range of challenging opportunities for graduate and post-graduate research, and this research is necessary to provide technological depth to the program.

In the European Union, where there have been strong government mandates to integrate sustainability with all levels of planning, including cultural heritage, exciting research opportunities have emerged. Recent research by the Centre for Sustainable Heritage at University College London in the United Kingdom has included advanced sensors for monitoring materials deterioration, computation fluid dynamics modeling of pollutant deposition in museums, and hygrothermic studies and modeling of building assemblies of archaic materials.[8]

Other sustainability research in the European Union has addressed the impacts of climate change, such as mapping the projected changes in climatic variables such as rainfall, solar radiation, acidity, pollutants and carbon dioxide concentrations, so that their future effects on buildings can be estimated, research that is equally beneficial to cultural heritage and civil infrastructure such as bridges.[9] This project sets the stage for research into the projected change in weathering rates of materials, and how to abate or mitigate the new environmental factors.

Summary

An education program of Preservation Engineering must be founded on an ethos of sustainability and respect for cultural heritage, integrating solid engineering research with learning opportunities for interdisciplinary collaboration in quantitative and qualitative problem solving, in order to prepare student engineers for conscientious and conscious practice in the realm of cultural heritage.

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[1] http://en.wikipedia.org/wiki/Sustainability Wikipedia, the free encyclopedia. Retrieved 03 June 2009.

[2] Brand, Stewart. *The Clock of the Long Now: Time and Responsibility: The ideas behind the world's slowest computer*. New York, NY: Basic Books, 1999.

[3] http://www.longnow.org/ The Long Now Foundation. Retrieved 03 June 2009.

[4] http://www.getty.edu/conservation/science/climate/climate_experts_roundtable.html The Getty Conservation Institute: Experts' Roundtable on Sustainable Climate Management Strategies. Retrieved 03 June 2009.

[5] http://www.ncptt.nps.gov/architecture-and-engineering-training/ National Center for Preservation Technology & Training: Architecture and Engineering Training. Retrieved 03 June 2009.

[6] http://www.ucl.ac.uk/sustainableheritage/module_3.htm Centre for Sustainable Heritage (CSH): Module 3 Sustainable Heritage: Sustainable Strategies. Retrieved 03 June 2009.

[7] http://www.engin.umich.edu/~problemsolving/thoughts.htm University of Michigan, School of Engineering: Thoughts on Problem Solving. Retrieved 3 June 2009.

[8] http://www.ucl.ac.uk/sustainableheritage/research.htm Centre for Sustainable Heritage (CSH): About Research at CSH. Retrieved 03 June 2009.

[9] http://noahsark.isac.cnr.it/overview.php Noah's Ark, Global Climate Change Impact on Built Heritage and Cultural Landscapes: Project Overview. Retrieved 03 June 2009.